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CONCLUSIONS.

1. The intratracheal inoculation of monkeys with three doses of pneumococcus Type I vaccine renders them completely immune against experimental pneumococcus Type I pneumonia.

2. The mere spraying of the throat with pneumococcus vaccine will not produce complete immunity against pneumonia in monkeys. Failure under these circumstances may be due to the fact that the monkey, by closing off the nasopharynx, prevents the vaporized vaccine from entering the trachea.

3. The immunity established by intratracheal injection of pneumococcus vaccine is probably cellular in character. Little or no protective substance against pneumococcus can be demonstrated in the serum of monkeys vaccinated by this method.

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SHIP FUMIGATION.

PRELIMINARY REPORT OF THE BOARD APPOINTED BY THE SURGEON GENERAL TO INVESTIGATE THE SUBJECT OF FUMIGATION OF SHIPS.

Because of the increasing requirements imposed by the quarantine laws of the United States and other countries, especially with reference to rodents, the Public Health Service has felt the need for further study of the whole subject of ship fumigation. For this reason the Surgeon General convened a board on March 1, 1922, consisting of a medical officer, a chemist, and an engineer to inquire into the subject and make recommendations.

In considering this matter the board arranged the work in two main divisions:

First. The investigation of the various gases which seem to offer advantages in ship fumigation, and experimentation regarding the production of these gases.

Second. The investigation of natural ventilation and artificial means of ventilation of ships after fumigation.

INVESTIGATION OF VARIOUS GASES FOR SHIP FUMIGATION.

The two gases which have been largely used for ship fumigation in the United States are hydrocyanic acid gas and sulphur dioxide. Each of these gases has certain advantages and disadvantages not possessed by the other. Neither is ideal. Carbon monoxide was used for a short time; but, while highly efficient, its use is restricted because of the complicated apparatus needed for its generation.

Sulphur dioxide has the advantages of being a fairly effective fumigant and of giving warning of its presence in time to allow the escape of any person within the quarters where the fumigant is being used. On the other hand, it has the disadvantage of being costly, it diffuses poorly, it is harmful to most tissues, articles of clothing, foodstuffs, seeds, etc., and the length of time for exposure—from 5 to 12 hours—is extremely important, from a financial standpoint, to the shipowners.

Hydrocyanic acid gas has the advantage of being very toxic in the percentage in which the gas is used, it is less costly than sulphur dioxide, it requires only a short period of exposure, and it does not affect foodstuffs, fabrics, clothing, etc. Its main disadvantages are that it is practically odorless and nonirritating, and that it is so highly toxic that a number of fatalities have occurred during its use.

From a study of the two gases now in use, certain requirements can be laid down which the ideal fumigant should meet. Briefly, these requirements are as follows: High toxicity; easy detection, by the senses, in sublethal concentration; harmlessness to foods; efficient penetrative qualities; nonpersistence; reasonably low cost; furnishes no fire or explosive hazard; and ease of manipulation. It should also be noncorrosive to metals and harmless to fabrics.

In determining where the experimental work should be done it was felt that on account of the wide experience of the Chemical Warfare Service of the Army with the various kinds of poison gases during the war and the familiarity of its officers with the production of such gases, the Edgewood Arsenal of that service would offer ideal facilities if such cooperation could be obtained.

When the matter was suggested to the Chief of the Chemical Warfare Service he immediately gave permission for the Public Health Service to use the facilities of the arsenal to the fullest extent and, in addition, made arrangement for the members of the board to reside at the arsenal during the actual experimental work. Certain personnel of the Chemical Warfare Service were detailed to cooperate in the experiments; others acted in an advisory capacity along special lines. The board desires to express its appreciation of the cooperation of those persons who so generously assisted in the experiments, and whose work contributed in a large measure toward making the final results successful.

Before the board planned its work a brief study had been made by the Public Health Service on the use of chloracetophenone gas with hydrocyanic acid gas. These studies brought out the fact that in such a mixture the tear gas remained long after the hydrocyanic acid gas had been dispersed. It also brought out the fact that these two gases tended to "layer out"—that is, to form pockets.

CYANOGEN CHLORIDE.

In reviewing the available literature the board gave special consideration to gases containing the cyanogen molecule, as it appeared that a number of these gases not only possessed the toxic effect of HCN, but also were tear gases. Cyanogen chloride was especially investigated, as its chemical and physiological properties seemed to conform so nearly to the requirements set down by the board. Work was therefore begun on a satisfactory method of production and a study of the practicability of its uses as a fumigant.

Methods of production.—Several tests were made with hydrochloric acid or sulphuric acid, sodium cyanide, and an oxidizing agent. The oxidizing agents which were used were manganese dioxide, sodium dichromate, sodium perchlorate, and sodium chlorate. These tests gave little or no lacrimation and were unsatisfactory. Sulphuric acid and salt, with sodium chlorate as an oxidizing agent, gave considerable lacrimation, but was considered undesirable because of delayed time of lacrimation and the predominance of hydrocyanic acid gas.

In the second series of experiments, bleach was used with hydrochloric acid and sodium cyanide. This method of production gave a very satisfactory quantity of cyanogen chloride. The main objections to this method were the danger of fire and the fact that the cyanogen chloride was given off when the bleach and cyanide were mixed, even before they were added to the acid. This method deserves further investigation.

In the third series of experiments, sodium cyanide and sodium chlorate were added to hydrochloric acid with and without the addition of talc. The qualities giving the most satisfactory results per 1,000 cubic feet were:

4 ounces powdered sodium cyanide;
3 ounces sodium chlorate;
2 ounces talc;
17 fluid ounces commercial hydrochloric acid, sp. gr. 1.20;
34 ounces water.

NOTE.—This formula is tentative and may be changed later.

First, the talc was mixed with the sodium chlorate, then the cyanide was added and mixed, and then the bag containing mixture was dropped into the dilute acid.

The composition of the lethal concentration as expressed in milligrams per liter is as follows:

Cyanogen chloride........	0. 9407
Hydrocyanic acid gas....	0. 3269

The purpose of the talc is to reduce the fire and explosive hazard. The friction and impact tests on the cyanide-chlorate talc mixture carried on by the Bureau of Mines for the Public Health Service showed that the fire and explosive hazard of the mixture was very small, except under extreme conditions not met with in actual usage.

The cyanogen chloride and hydrochloric acid gas mixture given above fulfills the following requirements:

(1) Toxicity: High toxicity with rodents, bats, roaches, bedbugs. (The amount required for lice requires further experimentation.)

(2) Detection properties: Intense lacrimation when lethal dose used. In 1/8 lethal dose (having no harmful effect on rats after exposure of one hour) lacrimation was still extreme.

(3) No effect on foods, tobacco, fabrics, leather, and no corrosive action on metals (with the possible exception of nickel).

(4) Efficient penetration qualities.

(5) Nonpersistence: Gas is not more persistent with hydrocyanic acid gas, probably less so.

(6) Reasonably low cost per 1,000 cubic feet. Cyanogen chloride mixture, $0.088; hydrochloric acid gas, $0.081.

(7) Fire and explosive hazards at minimum.

INVESTIGATION OF VENTILATION OF SHIPS.

At the request of the Surgeon General, the United States Shipping Board detailed one of its ships to the Public Health Service for the study of ventilation.

This part of the investigation has not as yet been completed, but the work has been along the following general lines:

(1) A study of the natural air currents in the holds of the ship under varying conditions of temperature, humidity, and wind velocity.

(2) A study of the air currents set up by artificial means of ventilation, such as blowers and fans, and the arrangement of the ducts of the blowers and the location of the fans to give the best results.

(3) A comparative study of natural ventilation and the various means of artificial ventilation in dispersing nontoxic heavy gases and cyanogen chloride.

(4) Practical application of cyanogen chloride in fumigation of holds and quarters on ship board.

As soon as the ventilation studies are finished, it is expected to present both the chemical and ventilation studies as a service publication.

FUMIGATION OF CARGOES OF CRATED VEGETABLES.

The question has recently arisen as to whether cargoes of crated onions, garlic, and potatoes landed at San Juan, P. R., provide means for the conveyance of rats, and therefore whether or not such cargoes